

## INTRAVENOUS VALPROATE FOR ACUTE TREATMENT OF MIGRAINE HEADACHE

### Related Applications

- 5 This application claims the benefit of prior-filed U.S. Provisional Patent Application Serial No. 60/132,416, entitled "Intravenous Valproate for Acute Treatment of Migraine Headache", filed May 4, 1999 (pending). The content of the referenced application is incorporated herein by reference.

### 10 Background of the Invention

- Migraine headache is a chronic and disabling condition affecting a significant portion of the population throughout the world. The pharmacologic management of migraine has traditionally focused on two approaches: symptomatic or acute treatment and prophylactic therapy. The objective of acute treatment is to reduce the intensity and duration of pain with its attendant symptoms and to optimize the patient's ability to function normally whereas the major objective of prophylactic therapy is the reduction of frequency, duration, and intensity of attacks.

- A variety of treatment strategies are available for the prophylactic treatment of migraines including beta-blocking drugs (*e.g.*, propranolol), amitriptyline, flunarizine, serotonin antagonists (*e.g.*, methysergide) and nonsteroidal anti-inflammatory drugs (*e.g.*, naproxen) are the major classes of agents that have been used in the prophylactic treatment of migraines. See *e.g.*, Deleu et al (1998) *Clin. Neuropharmacol.* 21:267-79 for review. Strategies for the acute treatment of migraines are also known which generally involve the use of simple analgesics, nonsteroidal anti-inflammatory drugs, antiemetics, narcotic analgesics, ergot derivatives, or serotonin-agonists, either alone or in combination. For example, dihydroergotamine (DHE) has been used for several decades for treatment of acute migraine headache and produces good relief in 70-80% of subjects at 2 hours after administration (Callaham and Raskin (1986) *Headache* 26:168-171). Sumatriptan produces similar efficacy, as do several newer serotonin 1B/1D receptor agonists (Cady *et al.* (1991) *JAMA* 265:2831-2835; Mathew *et al.* (1992) *Arch Neurol.* 49:1271-1276 and Rapoport (1997) *Cephalalgia* 17: 464-465).

- However, a significant portion of migraine patients remain who either require narcotic analgesic treatment or who may have significant disability despite the use of non-narcotic analgesia. A large number of patients go to hospital emergency

rooms for acute treatment of prolonged migraine headache (Klapper *et al.* (1991) 31:523-524). Many of those patients may have used an ergotamine or triptan so that use of DHE, injectable sumatriptan or other related compounds would be contraindicated. Also, cardiovascular risk factors limit the safety of triptan use or dihydroergotamine; the new DHE nasal spray (Migranal) carries the same warnings as the triptans. (Kelly (1995) *Neurology* 45:11-13; Maxalt:MSD, Ltd. (1998) Insert; and Physician's Desk Reference, 53 Edition, Medical Economics Comp. (1999) pp 2061). Finally, a number of patients presenting to the emergency room have associated analgesic rebound headache, with or without chronic daily headache, in which cases further analgesic use is problematic (Silberstein and Young (1995) *Drug Saf.* 13:133-144).

### **Summary of the Invention**

This invention is based on the discovery of an effective acute treatment for migraines which involves intravenous injection of valproate sodium, also referred to herein according to its tradename, Depacon™. In particular, it has been discovered that intravenous valproate is an alternative therapy for abortive treatment of moderate to severe prolonged acute migraine headache.

### **Detailed Description and Exemplification**

The present invention describes the results of studies using intravenous valproate ("VPA") for abortive treatment of acute migraine headache. The present studies were designed, in particular, to determine the possible effectiveness of intravenous administration of VPA for the treatment of acute migraine headache of significant duration. Accordingly, the invention provides methods of treating acute migraine headache in a subject in need of treatment. In one embodiment, the method involves administering to the subject an effective dose of intravenous valproate. Administration of intravenous valproate is preferably such that the severity and/or duration of acute migraine headache is lessened or reduced. Alternatively, administration is such that a symptom selected from the group consisting of nausea, photophobia, and phonophobia is lessened or reduced. In a preferred embodiment, about 100mg to 2000mg valproate are administered to a subject. Preferably about 200mg to 1500mg are administered, more preferably about 300mg to 1000mg are administered, and even more preferably about 250mg to 750mg of valproate are administered. In a particularly preferred embodiment, about 500mg valproate are administered to the subject. In another embodiment, the valproate administered to the subject is administered over 1 hour. In yet another embodiment, the valproate is

administered to a subject over 30 minutes. In yet another embodiment, the valproate is administered to the subject in more than one dose.

The invention is illustrated, in essence, by the following examples which should not be construed as limiting. The contents of all references cited throughout this application are hereby incorporated by reference.

### **Example 1: Pilot Study**

This Example describes the results of a pilot study using intravenous valproate for abortive treatment of acute migraine headache.

*Methods.* Patients with established diagnosis of migraine with and without aura were considered for randomization to intravenous ("IV") valproate ("VPA") or intramuscular ("IM") dihydroergotamine ("DHE") with metoclopramide, also referred to herein as Reglan®, for patients with moderate to severe migraine headaches of duration of 24 to 96 hrs. Patients received intravenous infusion of 500 mgs of valproate over 30 mins or 1 mg DHE with 10 mgs metoclopramide IM. Headache severity, presence of nausea, phonophobia and photophobia were rated at baseline, 1 hr, 2 hrs, and 4 hrs. Table I and II. There were 5 patients in each group.

*Results.* Of the 5 patients receiving valproate, 4 of the 5 had response of their headaches from moderate or severe to none or mild at 1 hr, 2 hrs, and 4 hrs. Of the 5 patients receiving DHE, 3 of the 5 patients had headache response to moderate or severe to mild or none at 1 hr, 2hrs, and 4 hrs. Table III. Of patients receiving valproate, 4 of 5 had nausea at baseline, 1 had nausea at 1 and 2 hrs, and all had relief of nausea at 4 hrs. In the DHE group, 2 of 5 had nausea at baseline, and 1 had nausea at 1 hr, 2 hrs, and 4 hrs. Table IVa. In the valproate group, all had photophobia at baseline, 4 of 5 had relief of photophobia at 1 hr and 2 hrs, and all had relief at 4 hrs. In the DHE group, 3 of 5 had relief of photophobia at 1 hr, 4 of 5 had relief at 2 hrs and 4 hrs. In the valproate group, 4 of 5 had relief of phonophobia at 1 hr, 2 hrs, and all had relief at 4 hrs. In the DHE group, 2 of 5 had relief of phonophobia at 1 hr, and 3 of 5 had relief of phonophobia at 2 hrs and 4 hrs. Table IVb.

*Conclusions.* Intravenous valproate is an alternative therapy for abortive treatment of moderate to severe prolonged acute migraine headache. Anti-convulsant mechanisms may be relevant to treatment of headache symptomatology.

## DEPACON IV 500 MG

TABLE I

Patient		0-h	1-h	2-h	4-h	24-h
JV	Headache Severity	3	0	0	0	0
	Nausea/vomiting	+	0	0	0	0
	Photophobia	+	0	0	0	0
	Phonophobia	+	0	0	0	0

Patient		0-h	1-h	2-h	4-h	24-h
KJ	Headache Severity	3	1	1	0	1
	Nausea/vomiting	+	0	0	0	0
	Photophobia	+	+	+	0	0
	Phonophobia	+	+	+	0	0

Patient		0-h	1-h	2-h	4-h	24-h
LF	Headache Severity	2	1	1	1	2
	Nausea/vomiting	0	0	0	0	0
	Photophobia	+	0	0	0	+
	Phonophobia	+	0	0	0	+

Patient		0-h	1-h	2-h	4-h	24-h
PD	Headache Severity	2	0	1	2	2
	Nausea/vomiting	+	0	0	0	+
	Photophobia	+	0	0	0	0
	Phonophobia	0	0	0	0	0

Patient		0-h	1-h	2-h	4-h	24-h
CH	Headache Severity	3	2	1	0	3
	Nausea/vomiting	+	+	+	0	+
	Photophobia	+	0	0	0	+
	Phonophobia	+	0	0	0	+

TABLE II

## DHE 1 mg Reglan 10 mg

Patient		0-h	1-h	2-h	4-h	24-h
DW	Headache Severity	3	2	2	2	
	Nausea/vomiting	+	0	+	+	
	Photophobia	+	+	+	+	
	Phonophobia	+	0	+	+	

Patient		0-h	1-h	2-h	4-h	24-h
EM	Headache Severity	2	3	3	3	1
	Nausea/vomiting	0	0	0	0	0
	Photophobia	+	+	+	+	0
	Phonophobia	0	+	+	+	0

Patient		0-h	1-h	2-h	4-h	24-h
JB	Headache Severity	3	0	0	1	1
	Nausea/vomiting	0	0	0	0	0
	Photophobia	+	0	0	0	0
	Phonophobia	+	0	0	0	0

Patient		0-h	1-h	2-h	4-h	24-h
AK	Headache Severity	3	1	N/D	0	0
	Nausea/vomiting	0	0	N/D	0	0
	Photophobia	+	+	N/D	0	0
	Phonophobia	+	+	N/D	0	0

Patient		0-h	1-h	2-h	4-h	24-h
CH	Headache Severity	3	0	0	0	2
	Nausea/vomiting	+	+	+	+	+
	Photophobia	+	0	0	0	+
	Phonophobia	+	0	0	0	0

TABLE III % Headache Relief

	1-h	2-h	4-h	24-h
Depacon	60	100	80	40
DHE/Reglan	60	50	60	

TABLE IVa. % Improvement of Migraine-associated Symptoms

% experiencing nausea	Depacon	DHE
0-h	80	40
1-h	20	20
2-h	20	50
4-h	0	40
24-h	40	

TABLE IVb

% experiencing photophobia	Depacon	DHE
0-h	100	100
1-h	20	60
2-h	20	50
4-h	0	40
24-h	40	

% experiencing phonophobia	Depacon	DHE
0-h	80	80
1-h	20	40
2-h	20	50
4-h	0	40
24-h	40	

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**Example 2: Expanded Study**

This Example describes an expanded study and analysis of the effectiveness of intravenous VPA for the treatment of acute migraine headache of significant duration.

- 5 Patient data from the pilot study described in Example 1 has been incorporated and further analyzed in addition to new patient data.

10 *Design.* Twenty patients with moderate to severe headaches of 24 – 72 hours duration were seen at the Western New England Headache Clinic. Patients alternately received intravenous VPA 500 mgs over 15 – 30 minutes, or dihydroergotamine (“DHE”) 1 mg with metoclopramide 10 mgs intramuscularly (“IM”). Age ranged from 22 to 73 years. Patients rated severity of headache, presence or absence of nausea, photophobia, and phonophobia at 1, 2 and 4 hrs. Table V and Table VI.

15 *Results.* In the 10 patients receiving DHE and metoclopramide, 40% had headache relief at 1 hour, 50% at 2 hours, 60% at 4 hours. The percent with nausea at 0, 1, 2, and 4 hours was 60%, 10%, 20%, 30% respectively, photophobia at 0, 1, 2, and 4 hours 100%, 50%, 50%, 40% respectively, phonophobia at 0, 1, 2, and 4 hours 80%, 30%, 50%, 40% respectively. In the 10 patients receiving i.v. VPA, 60% had headache relief  
20 at 1 hour, 70% at 2 hours, 70% at 4 hours, the percent with nausea at 0, 1, 2, and 4 hours was 70%, 30%, 30%, 20% respectively, photophobia at 0, 1, 2, and 4 hours was 100%, 40%, 40%, 30% respectively, and phonophobia at 0, 1, 2, and 4 hours was 90%, 40%, 40%, 30% respectively. Table VII.

25 *Conclusions.* The results of the present study indicate that intravenous VPA is at least as efficacious as DHE for abortive treatment of acute migraine. Accordingly, intravenous VPA offers a treatment option for migraine headache patients who have recently used a triptan or DHE without the risk of drug-drug interaction or cardiovascular complications.

TABLE V

DHE 1 mg IM Reglan 10 mg IM

Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
DW	24 hours	Headache Severity	3	2	2	2	0
		Nausea/vomiting	-	0	-	-	0
		Photophobia	-	-	-	-	0
		Phonophobia	-	0	+	-	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
EM	36 hours	Headache Severity	2	3	3	3	1
		Nausea/vomiting	0	0	0	0	0
		Photophobia	-	-	-	-	0
		Phonophobia	0	-	-	-	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
JB	24 hours	Headache Severity	3	0	0	1	1
		Nausea/vomiting	0	0	0	0	0
		Photophobia	-	0	0	0	0
		Phonophobia	-	0	0	0	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
CH	72 hours	Headache Severity	3	0	0	0	2
		Nausea/vomiting	+	-	-	+	-
		Photophobia	+	0	0	0	-
		Phonophobia	-	0	0	0	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
LH	72 hours	Headache Severity	3	3	2	0	0
		Nausea/vomiting	0	0	0	0	0
		Photophobia	+	-	+	0	0
		Phonophobia	+	+	+	0	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
GL	48 hours	Headache Severity	3	2	2	2	1
		Nausea/vomiting	+	0	0	0	0
		Photophobia	+	+	+	+	0
		Phonophobia	-	-	-	+	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
CR	72 hours	Headache Severity	3	0	0	0	1
		Nausea/vomiting	+	0	0	0	0
		Photophobia	+	0	0	0	0
		Phonophobia	+	0	0	0	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
MM	72 hours	Headache Severity	2	0	0	0	0
		Nausea/vomiting	+	0	0	0	0
		Photophobia	+	0	0	0	0
		Phonophobia	+	0	0	0	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
JC	24 hours	Headache Severity	2	2	3	3	1
		Nausea/vomiting	0	0	+	+	0
		Photophobia	+	+	+	+	0
		Phonophobia	0	0	+	+	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
MJ	48 hours	Headache Severity	2	2	1	1	1
		Nausea/vomiting	+	0	0	0	0
		Photophobia	+	0	0	0	+
		Phonophobia	+	0	0	0	-

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TABLE VI

Depacon IV 500 mg

Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
JV	24 hours	Headache Severity	3	0	0	0	0
		Nausea/vomiting	-	0	0	0	0
		Photophobia	-	0	0	0	0
		Phonophobia	-	0	0	0	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
KJ	48 hours	Headache Severity	3	1	1	0	1
		Nausea/vomiting	-	0	0	0	0
		Photophobia	-	-	-	0	0
		Phonophobia	-	-	-	0	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
LF	48 hours	Headache Severity	2	1	1	1	2
		Nausea/vomiting	0	0	0	0	0
		Photophobia	-	0	0	0	+
		Phonophobia	-	0	0	0	-
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
PD	48 hours	Headache Severity	2	0	1	2	2
		Nausea/vomiting	-	0	0	0	+
		Photophobia	+	0	0	0	0
		Phonophobia	0	0	0	0	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
CH	24 hours	Headache Severity	3	2	1	0	3
		Nausea/vomiting	+	-	-	0	+
		Photophobia	+	0	0	0	+
		Phonophobia	+	0	0	0	+
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
BL	72 hours	Headache Severity	2	1	1	1	2
		Nausea/vomiting	+	0	0	0	0
		Photophobia	+	+	+	+	+
		Phonophobia	+	+	+	+	+
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
MMC	48 hours	Headache Severity	3	3	2	2	1
		Nausea/vomiting	+	+	+	+	+
		Photophobia	+	+	+	+	+
		Phonophobia	+	+	+	+	+
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
MC	24 hours	Headache Severity	2	2	2	1	0
		Nausea/vomiting	0	0	0	0	0
		Photophobia	-	0	0	0	0
		Phonophobia	+	0	0	0	0
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
MJ	48 hours	Headache Severity	2	1	1	1	1
		Nausea/vomiting	0	0	0	0	0
		Photophobia	+	0	0	0	+
		Phonophobia	+	0	0	0	+
Patient	Headache Duration		0-h	1-h	2-h	4-h	24-h
LH	48 hours	Headache Severity	3	3	2	3	2
		Nausea/vomiting	+	+	+	+	+
		Photophobia	+	+	+	+	+
		Phonophobia	+	+	+	+	-

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TABLE VII

## ANALYSIS

## % Headache Relief

	1-h	2-h	4-h	24-h
Depacon	60	70	70	50
DHE	40	50	60	90

## % Improvement of Migraine-associated Symptoms

% experiencing Nausea	Depacon	DHE
0-h	70	60
1-h	30	10
2-h	30	20
4-h	20	30
24-h	40	10

% experiencing Photophobia	Depacon	DHE
0-h	100	100
1-h	40	50
2-h	40	50
4-h	30	40
24-h	60	20

% experiencing Phonophobia	Depacon	DHE
0-h	90	80
1-h	40	30
2-h	40	50
4-h	30	40
24-h	60	10

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**Example 3: Further Expanded Study**

This Example describes a further expanded study and analysis of the effectiveness of intravenous VPA for the treatment of acute migraine headache of significant duration. Patient data from the study described in Examples 1 and 2 have been incorporated and further analyzed in addition to new patient data.

*Design and Methods.* Participants (N = 40) were from age 14 to 74 and were established patients of the Western New England Headache Clinic. Patients called to report the pressure of prolonged moderate to severe migraine. They had no evidence of conditions other than migraine to cause headache and were medically stable. None of the patients had a known allergy to Depacon™ or DHE; none was pregnant. Patients received a neurological and general physical examination and filled out a four grade baseline headache rating from developed by Western New England Headache Clinic (see Table 2). The patients then received either 500 mg Depacon™ over 15-30 minutes administered in 100 ccs D5W, or 1 mg DHE intramuscularly preceded by 10 mg metoclopramide intramuscularly. Headache severity and associated symptomatology were rated 1, 2, and 4 hours.

*Results.*

A total of 40 patients were randomized, 20 in the Depacon™ group and 20 in the DHE group. Table VII summarizes the number of patients in each group by severity of headache (moderate or severe), demographic data and medication assignment.

Table VIII shows respond rate and headache severity for baseline, 1, 2 and 4 hours.

Table IX shows the associated symptomatology experienced at baseline, 1, 2 and 4 hours. The majority of patients had meaningful response in both groups, but the Depacon™ group responded somewhat better, although not statistically significantly ( $P>0.05$ ).

Table X shows the numbers and percentages of symptom free patients at 1, 2 and 4 hours.

Table VII: Baseline Patient Characteristics

		DHE (N=20)		Depacon® (N=20)	
<i>Gender</i>					
5	Female	18	(90%)	17	(85%)
	Male	2	(10%)	3	(15%)
<i>Age in Years</i>					
10	Mean (Range)	43.0	(14-71)	41.0	(14-73)
<i>Duration of Headache</i>					
	Mean (Range) in Hours	49.2	(24-96)	46.4	(24-75)
<i>Severity of Headache</i>					
15	Moderate	8	(40%)	6	(30%)
	Severe	12	(60%)	14	(70%)

Table VII: Responder Rate and Headache Severity \*

20		Baseline	1 hour	2 hours	4 hours
	Depacon	2.7	1.8 (50%)	1.5 (60%)	1.4 (60%)
25	DHE	2.6	1.5 (45%)	1.4 (50%)	1.2 (60%)

Table IX: Associated Symptomatology

30 Number (or %) of Patients Who Reported Nausea

	Baseline	1 hour	2 hours	4 hours
Depacon®	15 (75%)	8 (53%)	8 (53%)	7 (47%)
DHE 12	(60%)	5 (42%)	6 (50%)	6 (50%)

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Number (or %) of Patients Who Reported Photophobia

Depacon®	20 (100%)	14 (70%)	10 (50%)	9 (45%)
DHE 12	20 (100%)	15 (75%)	13 (65%)	11 (55%)

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Number (or %) of Patients Who Reported Phonophobia

Depacon®	19 (95%)	14 (74%)	11 (58%)	10 (53%)
DHE 12	18 (90%)	12 (67%)	12 (67%)	11 (61%)

Table X: Symptom Free Patients in Each Group at 4 hours (no headache or associated symptomatology)

	Symptom Free at 1 hour	Symptom Free at 2 hours	Symptom Free at 4 hours
Depacon® (N=20)	2 (10%)	3 (15%)	5 (25%)
DHE (N=20)	3 (15%)	5 (25%)	6 (30%)

*Analysis.* This study demonstrates that Depacon™ is an effective symptomatic treatment for migraine headache and comparable in efficacy to DHE. Depacon™ appears to act as an abortive migraine medication, possibly by a GABAergic mechanism. (Cutrer *et al.* (1997) *Cephalalgia* 17:93-100). Headache associated symptomatology responded equally well and comparably to the combination of DHE and metoclopramide. The cohort treated with Depacon™ was remarkably free of adverse event; all were independent and returned to home after receiving treatment. This is especially remarkable in view of the fact that headache, nausea and vomiting are listed among the adverse side effects associated with both divalproex sodium (Depakote™) and intravenous valproate (Depacon™) treatments.

Depacon™ is FDA approved for treatment of epilepsy and has a favorable safety profile. We had no adverse events in any of the 20 patients receiving 500 mg Depacon™ given during 15 to 30 minutes infusion. In the typical migraineur who presents in a clinic or emergency room, Depacon™ could be used advantageously among those who have recently used an ergotamine or triptan, since there is no significant drug-drug interaction between Depacon™, ergotamine or triptan.

Divalproex sodium tablets (Depakote™) have been reported to be useful for preventative treatment of migraine headaches with or without aura, with several studies showing efficacy (Jensen *et al.* (1995) *Arch Neurol.* 52:281-286 and Hering and Kuritzky (1992) *Cephalalgia* 12:81-84). The FDA has approved Depakote™ for prevention of migraine headaches. However, the studies described herein (*e.g.*, Examples 1-2) represent the first demonstration of the use of intravenous valproate, Depacon™, for abortive treatment of acute migraine headaches. This novel therapy

offers a treatment option with little risk of drug-drug interaction or cardiovascular complications for migraine patients who have recently used an ergotamine or triptan.

In these pilot studies, Depacon™ is determined to be at least comparable to the traditional combination of DHE and metoclopramide in headache relief and associated symptomatology. Although the DHE and metoclopramide were administered intramuscularly in this study, it is unlikely this method of administration affected the degree of relief, or time of action, for these patients compared to intravenous DHE and metoclopramide administration.

*Conclusion.* Depacon™ is equal to and in some respects superior to dihydroergotamine therapy for abortive treatment of prolonged moderate to severe acute migraine headache. Depacon™ offers an effective therapy option when patients' ergotamine or triptan use presents the possibility of adverse drug interactions or cardiovascular effects that may be consequent to dihydroergotamine therapy (*e.g.*, patients who have had use of ergotamine or triptan within 24 hours prior to clinic or emergency room arrival). Depacon™ would not be associated with analgesic rebound, or patients' inappropriate medication-seeking that the use of narcotic analgesics can promote.

#### **Equivalents**

Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention described herein. Such equivalents are intended to be encompassed by the following claims.